

Expert system for stored malting barley quality maintenance

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QualiGrain

http://www.bordeaux.inra.fr/qualigrain

Expert system for stored malting barley quality maintenance

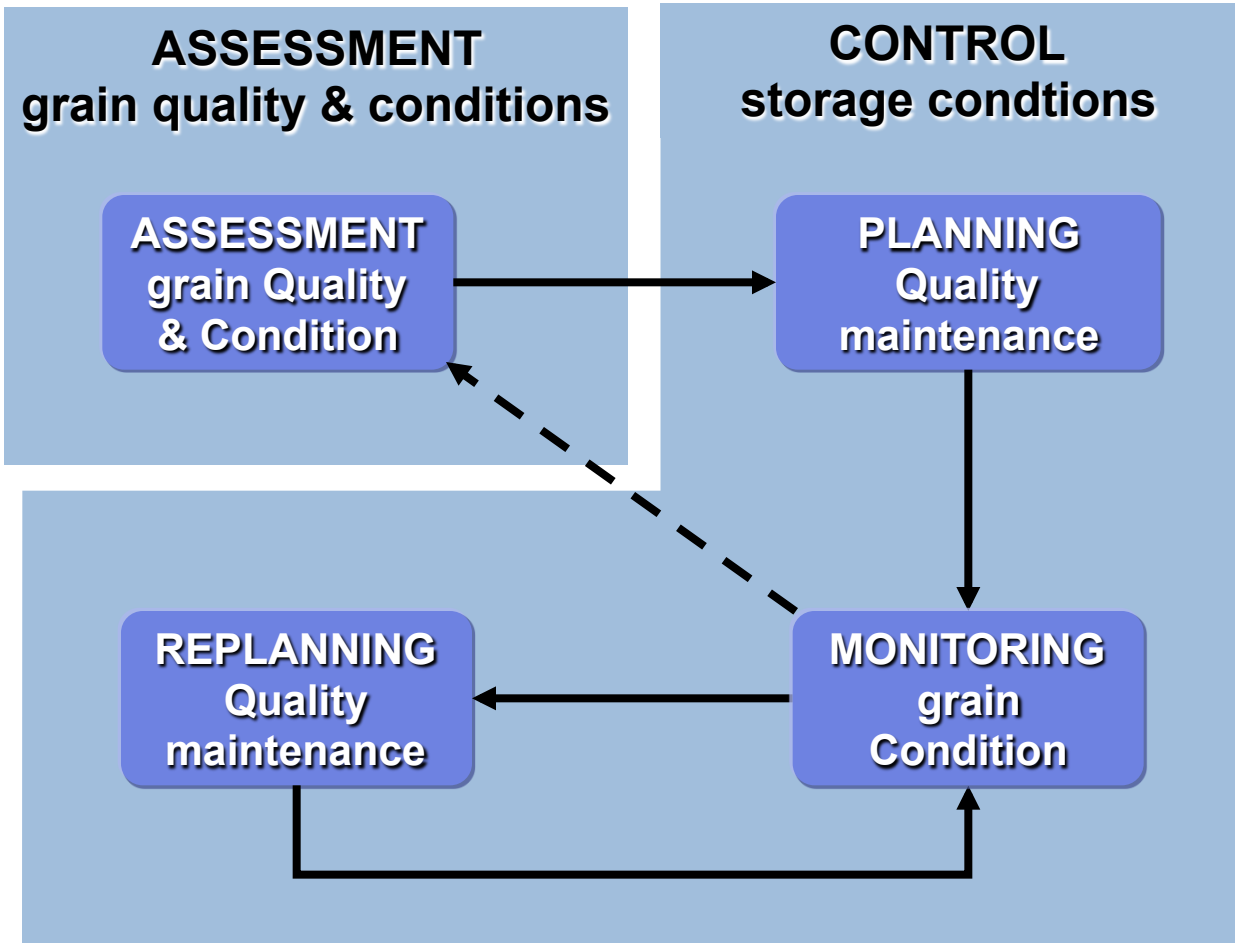
Système expert de gestion de la qualité de l'orge de brasserie stockée

Amadou Ndiaye

INRA

France

Preventive strategy

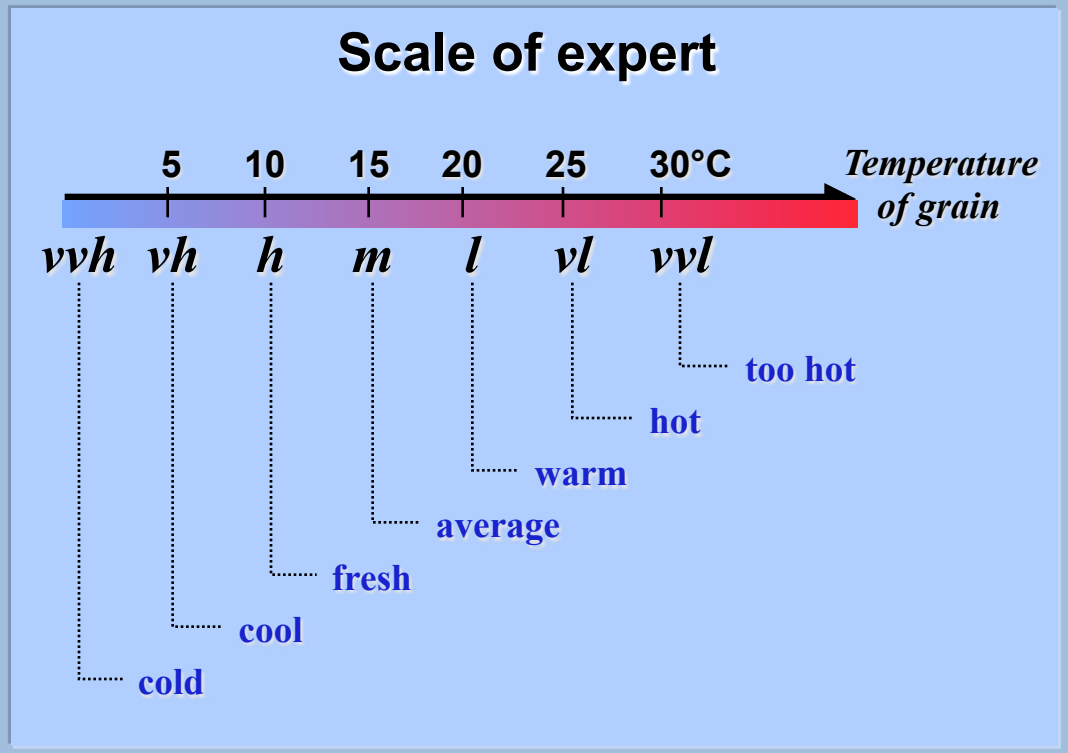


Quality

***f*(Physico-chemical Caracteristics,
Sanitary-Safety caracteristics,
Technological potential,
Nutritional potential)**

Assessment of Grain Quality

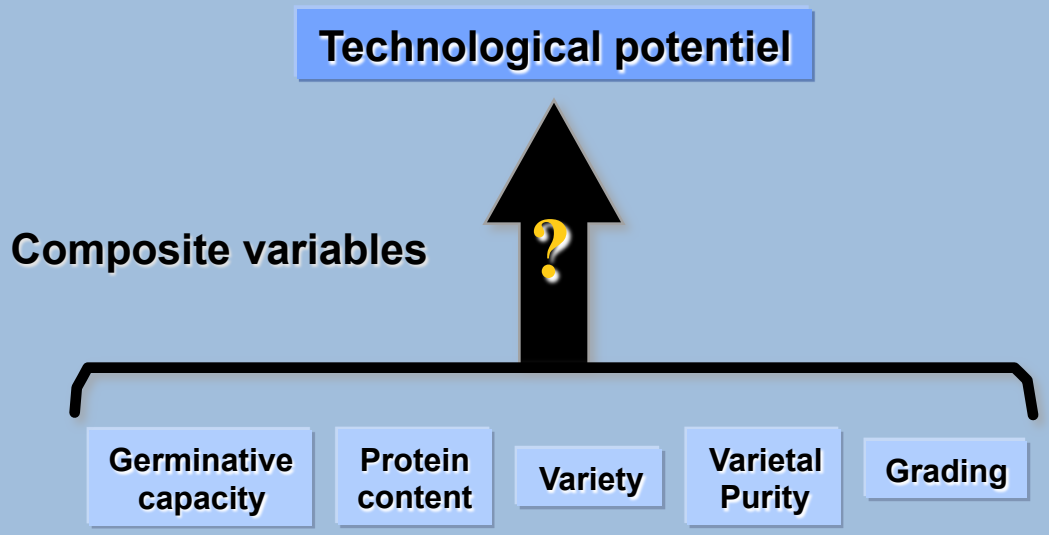
Grain Quality Space



- **7 elements symbolic space**
  {vvl, vl, l, m, h, vh, vvh}
- **Ordered space**
  vvl < vl < l < m < h < vh < vvh
- **2 basic functions *pred* and *suc***
  pred(m) = h, *pred*(vvh) = vvh
  suc(m) = l, *suc*(vvl) = vvl
  pred(*suc*(m) = *suc*(*pred*(m) = m
  pred(*pred*(m)) = vh, *suc*(*suc*(m) = vl
- **3 comparison operators**
  eq, gt, lt
- **4 composing operators**
  min, max, min-max, max-min
  min(x,y)=x ⇔ x *lt* y
  max(x,y)=x ⇔ x *gt* y
- ***Ad-hoc* operators**
  α, β ...

Assessment of Grain Quality

Human experts cognitive operations

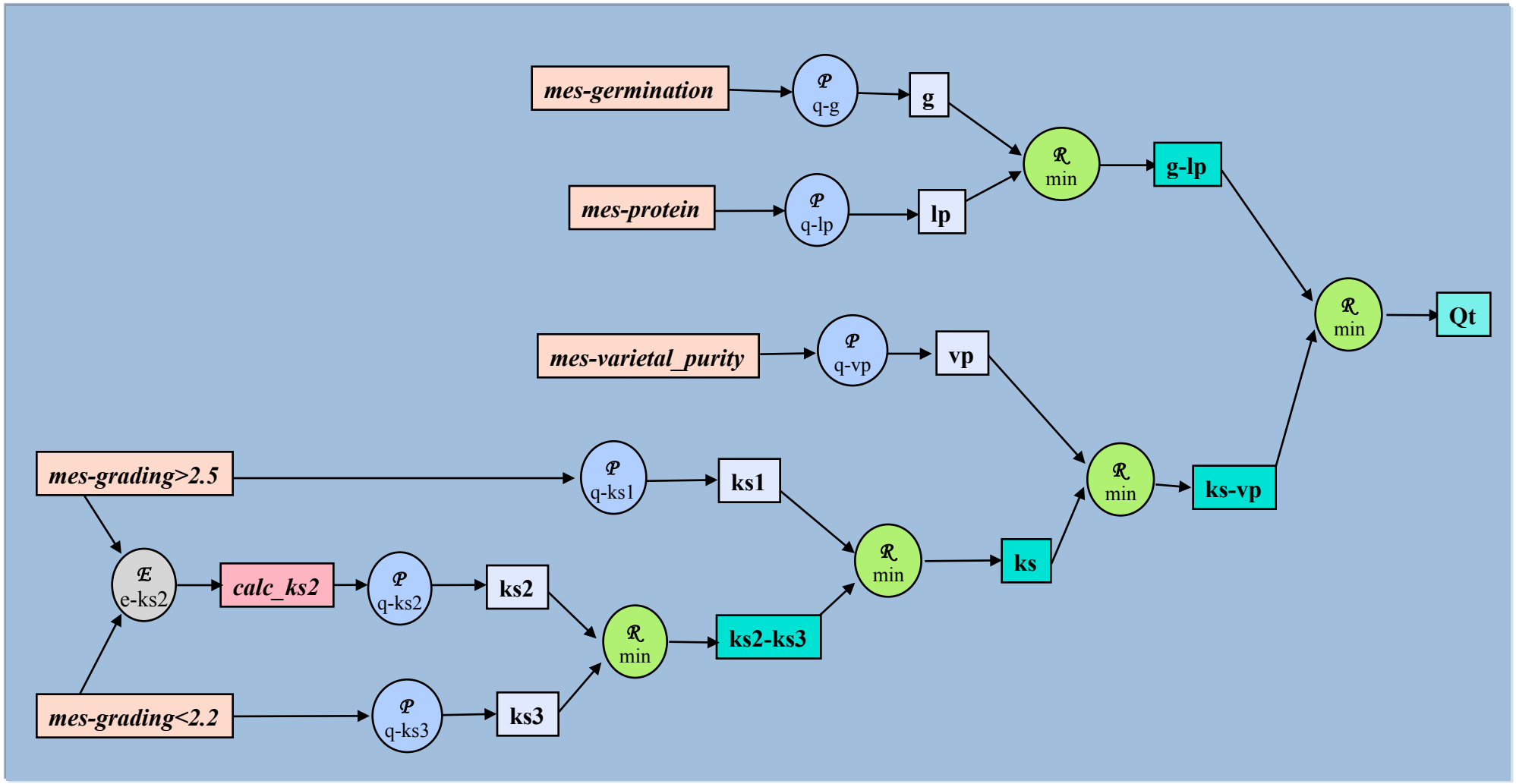


7 Abstracts operations

- **Projection** ($\mathcal{P}_j$)
  $\mathcal{P}_j$: R → Q or V → Q
- **Reduction** ($\mathcal{R}$)
  $\mathcal{R}$: QxQ → Q
- **Deduction** ($\mathcal{D}$)
  $\mathcal{D}$: QxQ → Q or Q → Q
  or Q → V or V → V
  or VxV → R
- **Induction** (I)
  I : Q → Q
- **Prediction** ($\mathcal{P}$)
  $\mathcal{P}$: R → Q or RxR → Q
- **Critic** (C)
  C: Q → V or QxQ → V
- **Equation** ($\mathcal{E}$)
  $\mathcal{E}$: R^n → R with n>0

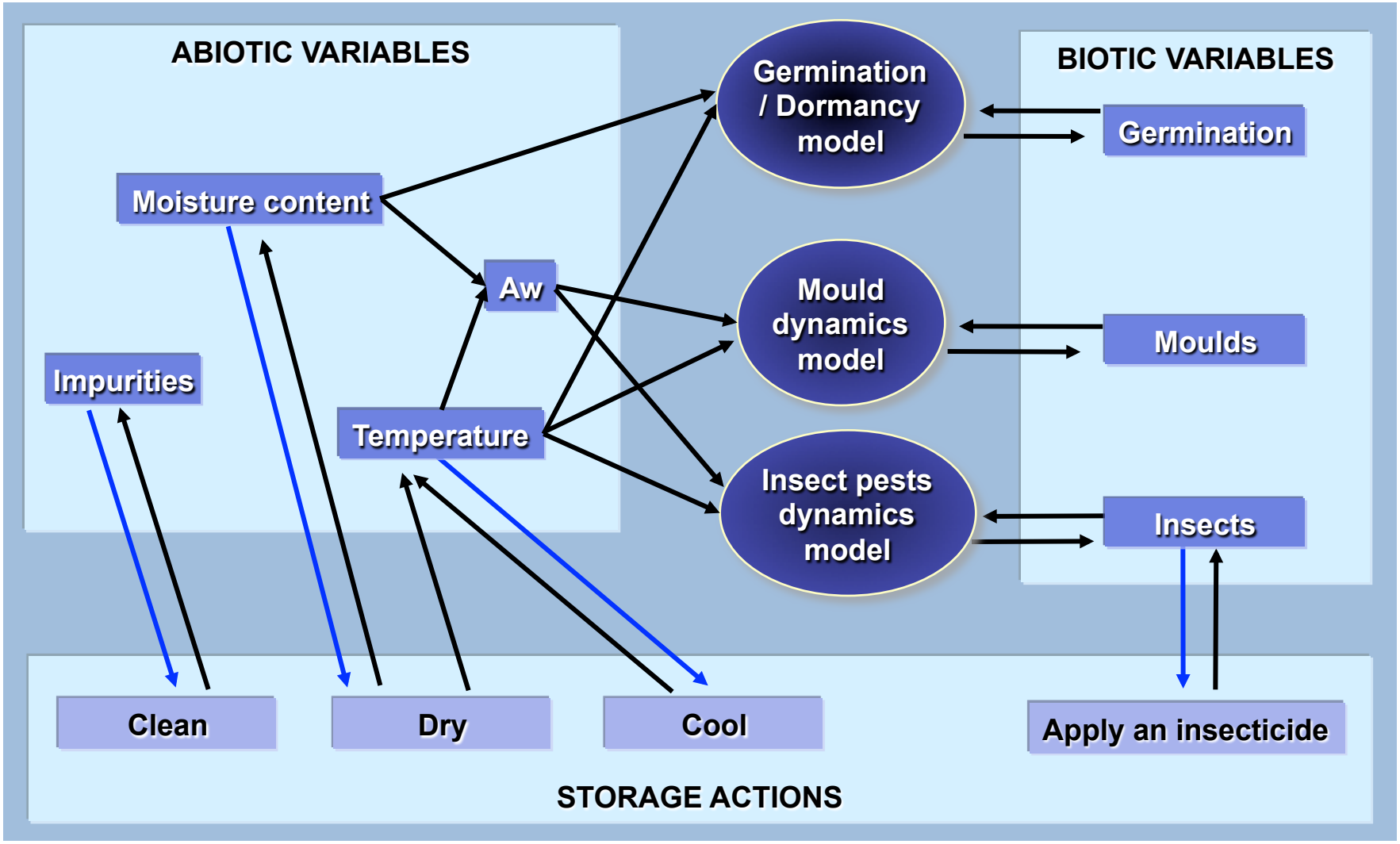
Assessment of Grain Quality

Technological potential



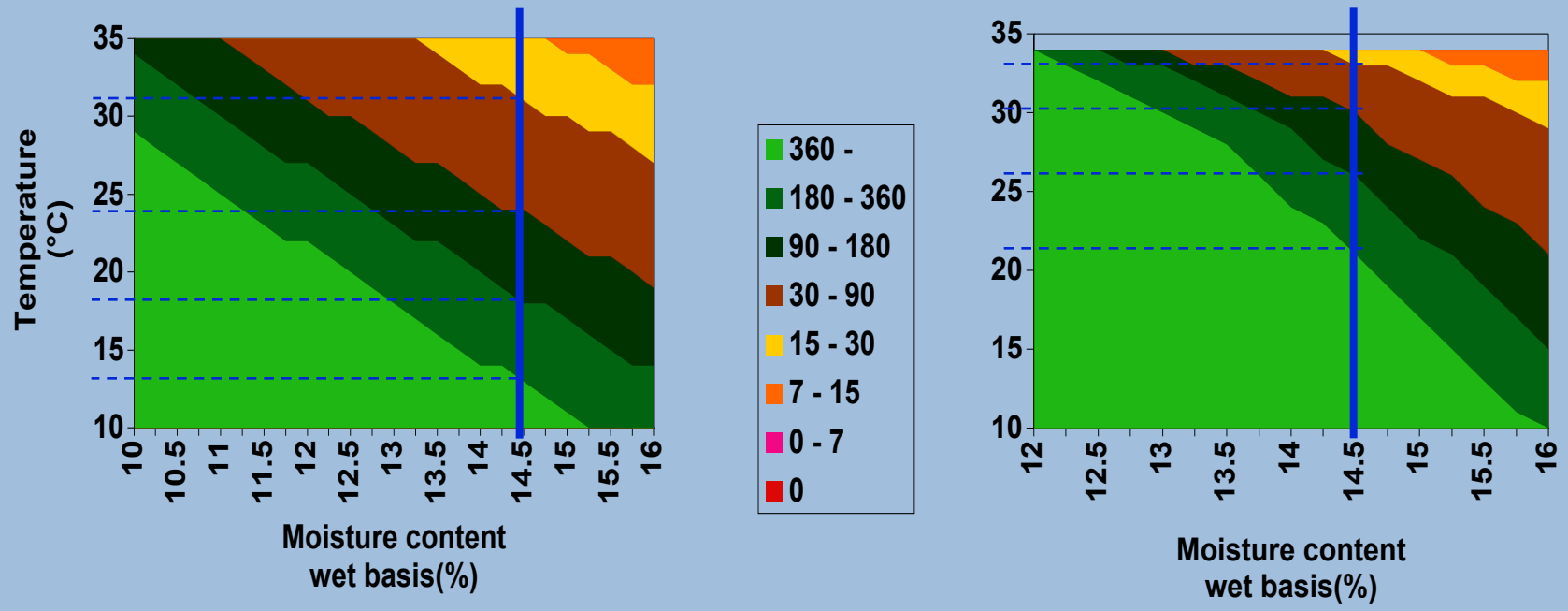
Control of storage condtions

Planning of quality maintenance



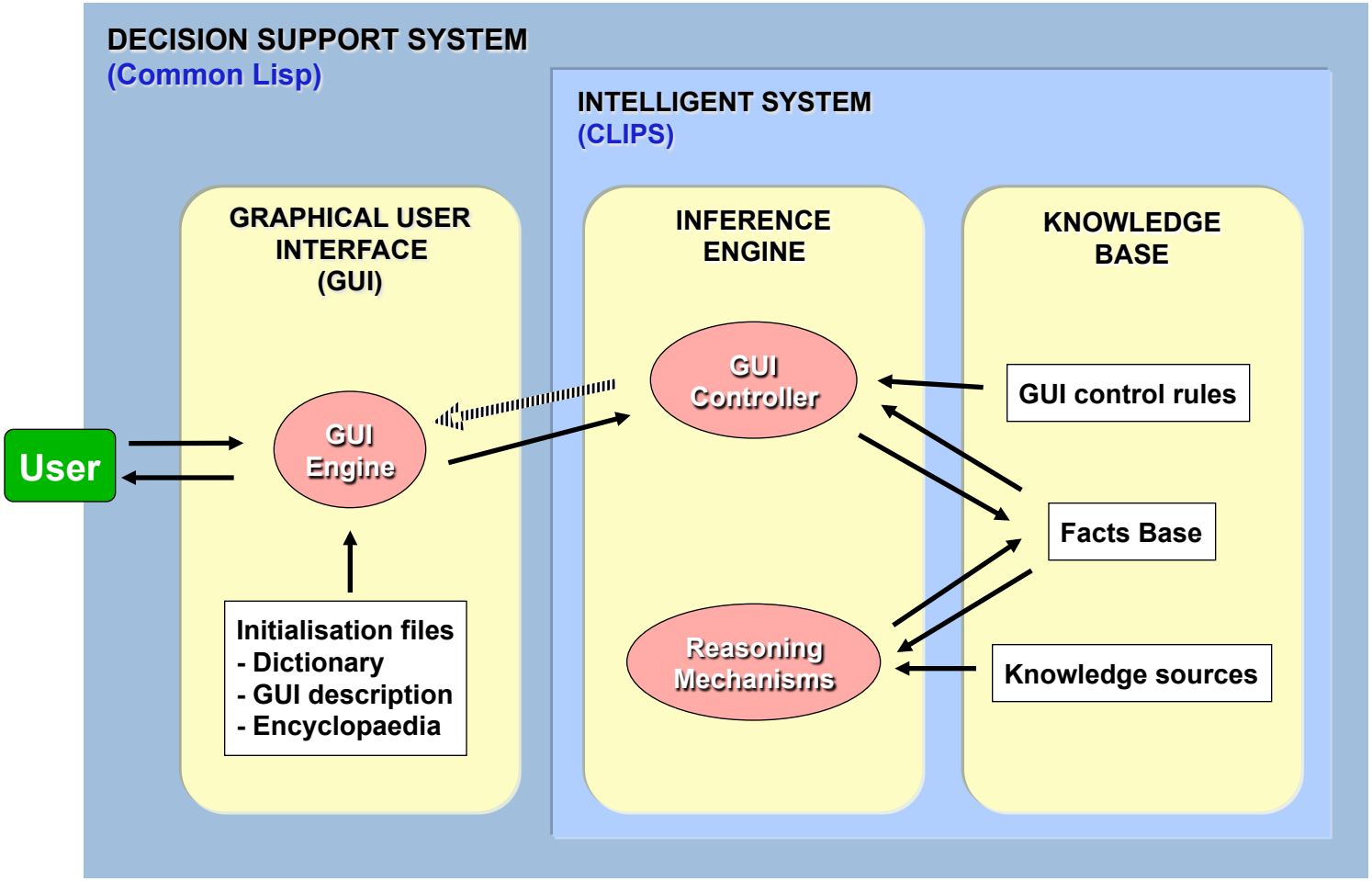
Control of storage condtions

Stability zone: Monitoring of grain condition

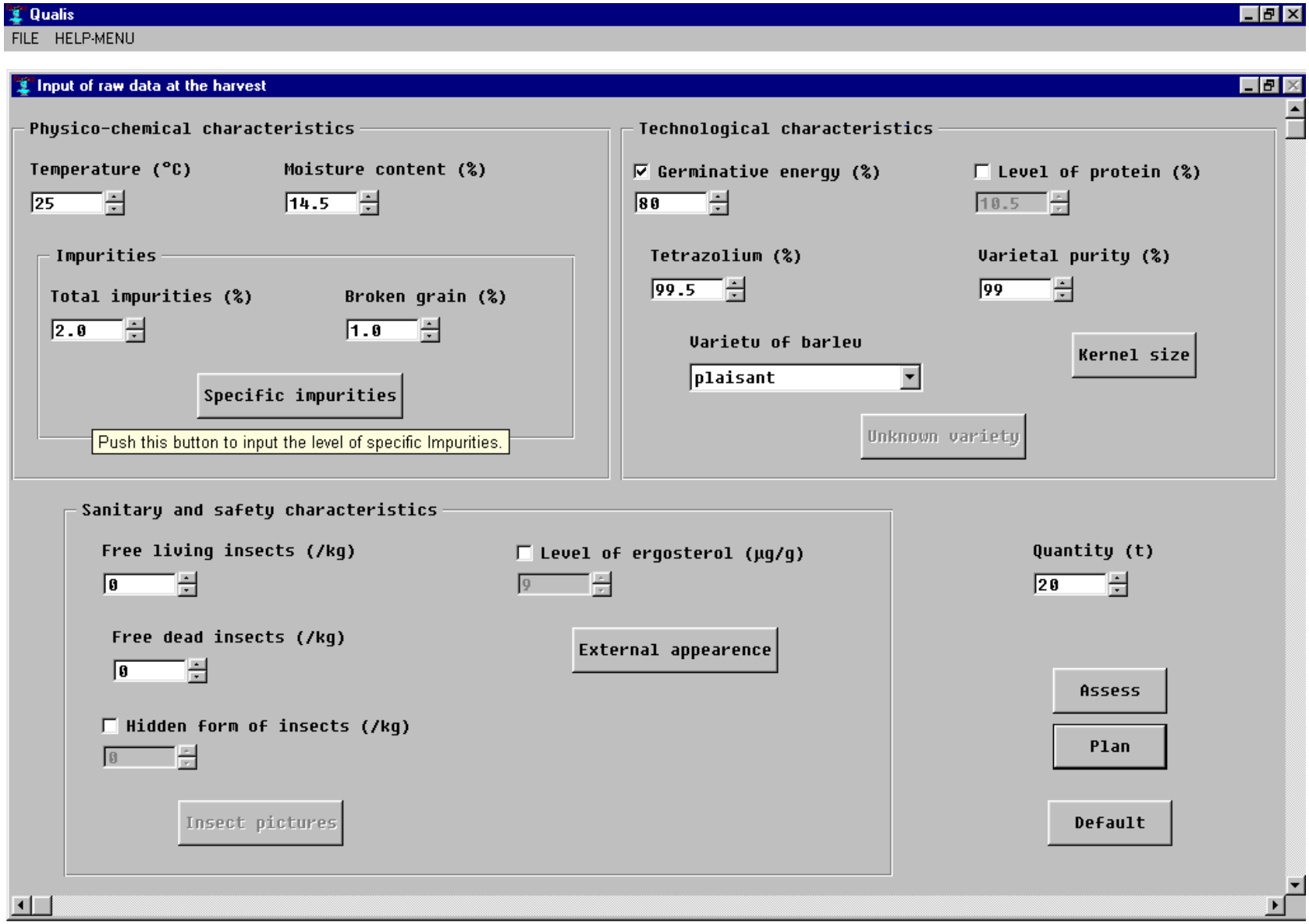


Implementation

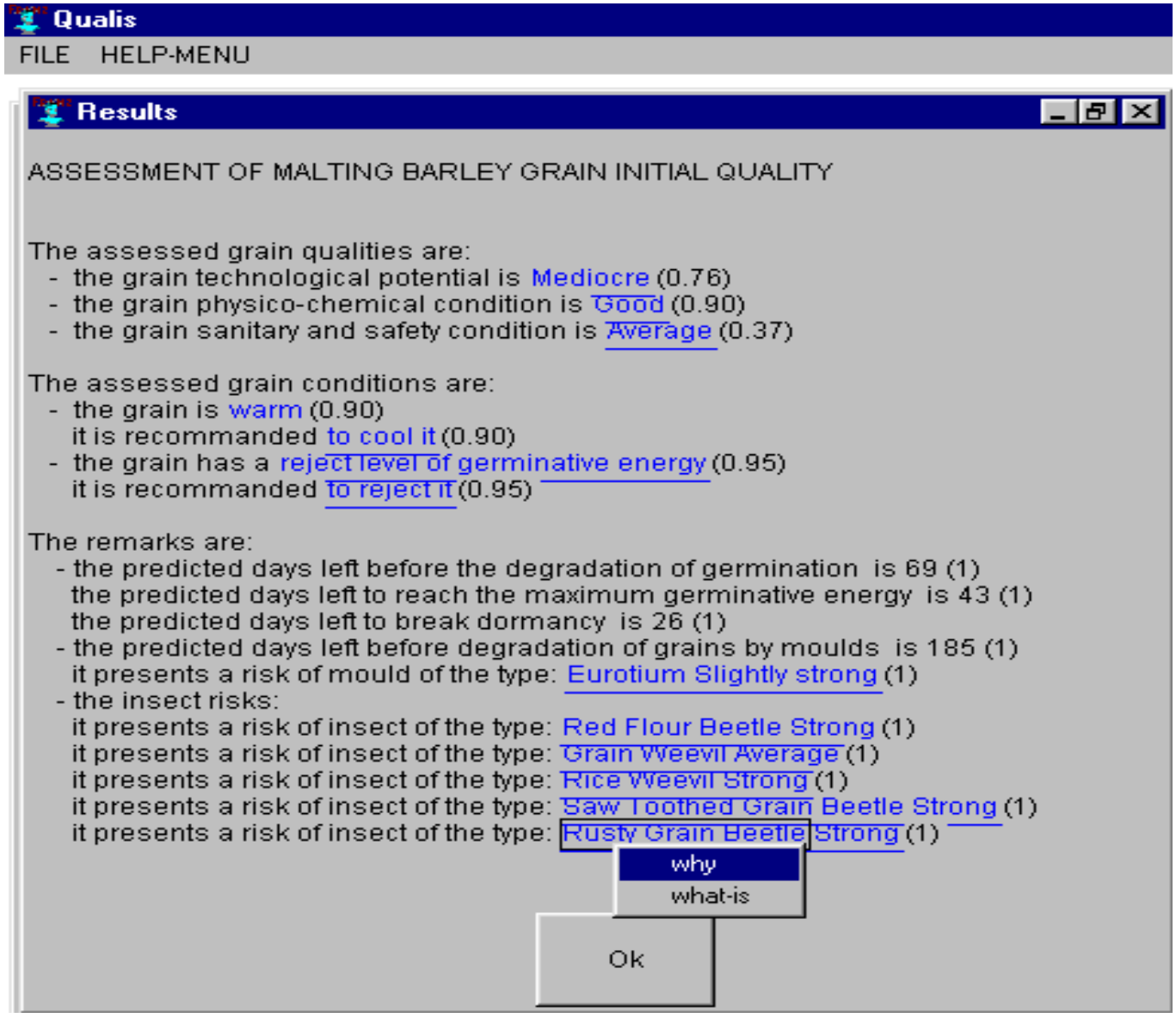
Flexible modular architecture



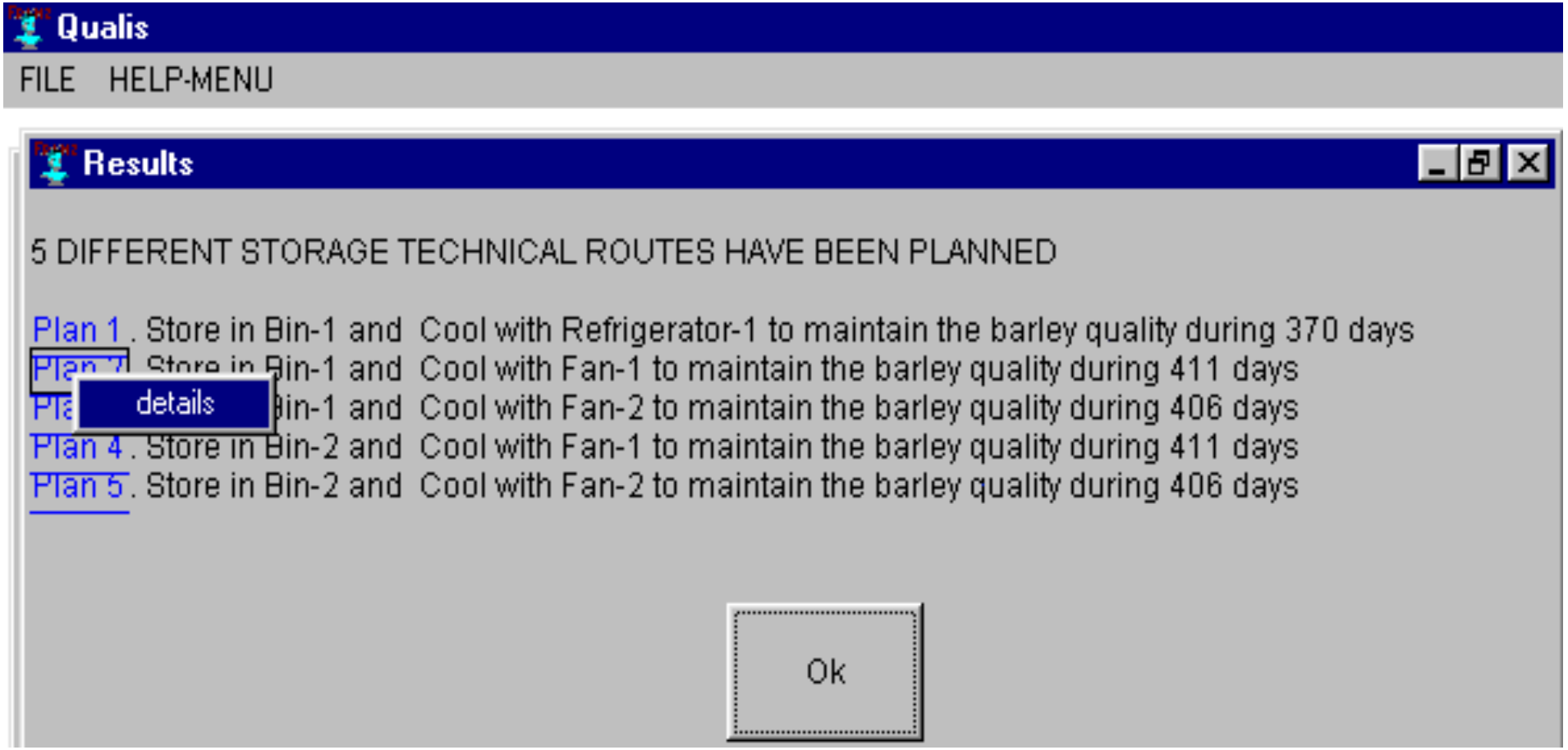
Input of raw data



Assessment of malting barley quality and condition



The optimal storage technical routes



The detail of the PLAN 2

Qualis

FILE HELP-MENU

Results

PLAN 2

2 storage oprations to carry out during 48 days to maintain the barley quality during 411 days

Initial grain condition:
germinative capacity 80%, temperature 25°C, moisture content 14.50%, activity of water 0.73,
level of impurities 2.00%, free living insects 0/kg, free dead insects 0/kg, insecticide none
The estimated safe storage periodes in the same grain condition are 69 days for the germinative capacity,
26 days for the dormancy break, 43 days for the maximum germinative energy and 185 days for the moulds

1. Store grain in the vertical bin Bin-1
Grain condition:
germinative capacity 80%, temperature 25°C, moisture content 14.50%, activity of water 0.73,
level of impurities 2.00%, free living insects 0/kg, free dead insects 0/kg, insecticide none
The estimated safe storage periodes in the same grain condition are 69 days for the germinative capacity,
26 days for the dormancy break, 43 days for the maximum germinative energy and 185 days for the moulds

2. Cool grain using the fan Fan-1 in 3 steps to reach 10°C of temperature in 48 days for an estimated period of 228 days
Step 1 to reach 22°C of temperature in 4 days for an estimated period of 180 days
The estimated safe storage periodes in the same grain condition are 104 days for germinative capacity,
31 days for dormancy break, 59 days for maximum germinative energy and 284 days for moulds
Step 2 to reach 15°C of temperature in 18 days for an estimated period of 180 days
The estimated safe storage periodes in the same grain condition are 257 days for germinative capacity,
21 days for dormancy break, 104 days for maximum germinative energy and 690 days for moulds
Step 3 to reach 10°C of temperature in 26 days for an estimated period of 180 days

Grain condition:
germinative capacity 96.99%, temperature 10°C, moisture content 14.50%, activity of water 0.70,
level of impurities 2.00%, free living insects 0/kg, free dead insects 0/kg, insecticide none
The estimated safe storage periodes in the same grain condition are 460 days for the germinative capacity,
0 days for the dormancy break, 138 days for the maximum germinative energy and 1309 days for the moulds

=> IT IS RECOMMANDED TO CONTROL THE PRESENCE OF INSECTS IN 411 DAYS

****

THE DELAY NECESSARY FOR A SUFFICIENT DECREASING OF THE TEMPERATURE BETWEEN
TWO COOLING AERATION STEPS IS NOT ACCOUNTED FOR IN THIS DEMO VERSION

****

Ok

The detail of the PLAN 2

PLAN 2

2 storage oprations to carry out during 48 days to maintain the barley quality during 411 days

Initial grain condition: GermC 80%, T 25°C, mc 14.50%, Aw 0.73, Imp 2%, insect 0/kg

The estimated safe storage periodes in the same grain condition are

Germinative capacity 69d and Moulds 185d (DormB 26d, maxGermC 43d)

1. Store grain in the vertical bin Bin-1

Grain condition: GermC 80%, T 25°C, mc 14.50%, Aw 0.73, Imp 2%, insect 0/kg

The estimated safe storage periodes in the same grain condition are

Germinative capacity 69d and Moulds 185d (DormB 26d, maxGermC 43d)

The detail of the PLAN 2

2. Cool grain using the fan Fan-1 in 3 steps to reach 10°C of temperature in 48 days for an estimated period of 228 days

Step 1 to reach 22°C of temperature in 4 days for an estimated period of 180 days

The estimated safe storage periodes in the same grain condition are

Germative capacity 104d and Moulds 284d (DormB 31d, maxGermC 59d)

Step 2 to reach 15°C of temperature in 18 days for an estimated period of 180 days

The estimated safe storage periodes in the same grain condition are

Germinative capacity 257d and Moulds 690d (DormB 21d, maxGermC 104d)

Step 3 to reach 10°C of temperature in 26 days for an estimated period of 180 days

Grain condition: GermC 96.99%, T 10°C, mc 14.5%, Aw 0.7, Imp 2%, insect 0/kg

The estimated safe storage periodes in the same grain condition are

Germinative capacity 460d and Moulds 1309d (DormB 0d, maxGermC 138d)

=> IT IS RECOMMANDED TO CONTROL THE PRESENCE OF INSECTS IN 411 DAYS

The delay necessary for a sufficient decreasing of the temperature between two cooling aeration steps is not accounted for in this demo version

Conclusions

- Representation of a heterogeneous complex system
- Mixed quantitative and qualitative reasoning
- Integration of mathematics models and expert knowledge
- Integration of time
- Implementation of a prototype on a PC computer: *QualiS©*
- Validation by the experts
- Validation in pilot scale experiments 10 tons (DK) & 20 tons (UK)

Prediction of the duration of cooling aeration and its effects to refine

Acknowledgements

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Collaborators

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